For convenience of reference the accepted name and synonomy may here be summarized.

Puccinia sambuci (Schw.) Arthur. Bot. Gaz. 35:15. Jan. 1903.

Aecidium sambuci Schweinitz. Trans. Am. Phil. Soc. Philadelphia, 4:294. 1834.

Puccinia bolleyana Saccardo. Am. Mon. Micr. Jour. 10:1 (fig.) Aug. 1889. Sylloge Fungorum, 9:303 (descr.) 15 Sept. 1891.

Puccinia atkinsoniana Dietel. Bull. Cornell Univ. (Science), 3:19. June 1897.

Puccinia thompsonii Hume. Bot. Gaz. 29:352. May 1900.

ELEMENTARY MYCOLOGY.

(Continued.)

W. A. KELLERMAN.

Origin of Living Matter. — The doctrine that individuals invariably arise from previously existing organisms was scientifically established the latter part of the century just closed. It had been previously supposed that some of the simple plants and animals, even some of the more complex organisms also, arose by "spontaneous generation"; *i. e.* that they were formed, often in great abundance, under favorable circumstances, directly out of inert or lifeless (mineral) matter. The experiments of some investigators seemed to prove the truth of such an hypothesis. But the classic work of Pasteur, and especially the crucial experiments of Tyndall, and Huxley, completely demonstrated the fallacy of such supposed spontaneous origin. They showed that new individuals appeared only when there were present the "germs," ova, spores, or seeds, derived from parent forms. The continuity of life is a proposition tenable not only for the existing races of plants and animals, but it is in the same manner demonstrated as well for the entire period of organic existence on our globe from early geologic time. Exactly when or how in archaean time living organisms began, no definite knowledge is at hand and no satisfactory hypothesis has been promulgated. Modern scientific research has clearly indicated that the old view of a radical (fundamental) difference between what is termed mineral or "inert" matter and organic or so-called "living" matter, is irrational. It is, moreover, highly probable that living matter, that is to say, organisms — a common though indefinite synonomous term is *"life"*—began to exist in an orderly natural way. Neither is it a gratuitous assumption, or fallacy, groundless, that organisms may have been in existence previous to the time when our globe was yet untenable by even the lower plants and animals. The

facts lending support to this view are, that some organisms are to-day flourishing in media of great extremes of temperature — for example in thermal springs and in arctic regions. Again, seeds subjected for a time to a temperature of 250° C. below zero do not all loose their vitality and they doubtless are more sensative to an untoward environment than less complex structures would be; but this is approximately the coldness of interplanetary space, and would suggest that ultra-imported living matter might have been the starting point for mundane organic existence.

VEGETATIVE REPRODUCTION. — Whatever the facts may prove to be in regard to the origin and continuity of living matter, the orderly (natural) rôle of multiplication of individuals at the present time is recognized and the processes involved in reproduction are, in a measure, understood. Leaves or portions of leaves of Begonia are placed in moist sand, whereupon they develop buds and shoots; and thus the florist obtains a new set of individual plants. Willow twigs, elder, etc., partially covered with moist soil may grow into so-called new individuals. Cuttings of very many ornamental or useful plants are used to provide the desired number of new individuals. Fragments of roots or portions of stems may in some cases be similarly used. In other cases such structures as runners, stolons, offsets, and bulbs are employed. The "artificial" multiplication of useful plants, particularly the various kinds of fruit trees, is secured by means of "budding" and "grafting," *i. e.* by the use of buds or twigs taken from the particular individuals or kinds which it is desired to perpetuate, and inserting on seedling plants, readily grown in great quantities, of similar (or closely related) species. In nature we see extensive vegetative multiplication by "sprouts" that develop from adventitious buds arising on roots; runners, stolons, or bulbs, may develop new plants at varying distances from the parent. Another mode of rapid and extended multiplication is seen in case of creeping underground stems which are called *rhizomes;* a large number of the Grasses and many other perennial herbaceous plants, including some of the Ferns, are common illustrative examples. The unicellular plants, as some of the Algae, the Bacteria, and many of the Fungi, multiply by a division of the cell into two equal parts, each of which is therefore a new individual (Fig. 2). The Yeast-plant increases by a process that is called "budding." (Fig. 4.) Here a small portion grows out from the parent cell, gradually enlarges and exhibits the usual elliptical shape; presently it may give rise to others and ultimately all may become detached. In some of the filamentous Algæ the cells divide repeatedly, and then fragments of the parent individual separate and these behave thereafter as new and independent plants. Larger or smaller portions of the ordinary or specialized vegetative cells in plants of still higher groups become detached and these continue an independent exist-

ence. The parts detached may be very small and simple in structure or they may be more complex and even highly differentiated. Illustrative examples are *"soredia"* in the Lichens, the *"gemmae"* in Liverworts and Mosses, *"hibernacula"* in Water Milfoil, *bulblets* in many plants, also *viviparous* inflorescences. The term *vegetative reproduction* is applied to all of the enumerated cases; it is the single cell, or the mass of cells, which is directly concerned in the vegetative processes of nutrition and growth that — still retaining (at least in large part) the normal functions — gives origin to the new individuals.

SPORE REPRODUCTION.— All or the great majority of cells in plants may be said to be nutritive in function; that is, they are or have been concerned, directly or indirectly, in the ordinary processes of nutrition and growth. But a cell may become physiologically differentiated for quite another purpose; it may loose its nutritive function entirely and all of its energies become set to the direct or indirect production of a new individual. Such a cell, having taken on a reproductive function, is called a *spore*. An example common and easily examined is furnished by the Leaf Mildew of the Lilac. The elongated vegative cells (hyphae) creep over the surface, sending suckers (called *haustoria*) into the epidermal cells of the host for nourishment. Presently some of the hyphae grow erect and near the end of such an upright *conidiophore* (as it is termed) constriction of the wall takes place; this deepens and finally the terminal portion is wholly abstricted; such a reproductive cell, or a sexaul spore, is called a *conidium*

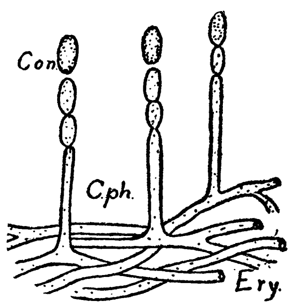

FIG. 7.

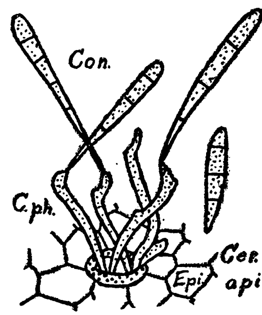

FIG. 8.

FIG. 7. Hyphæ of a Leaf Mildew (Ery.), with conidiophores (C.ph.) abstricting conidia (Con.). The fungus grows on the surface of the leaf.

FIG. 8. Hyphæ (C.ph.) of the Celery Leaf-spot fungus, Cercospora apii (Cer. apii.), emerging through the stomate of a leaf and bearing Conidia (Con.).

(Fig. 7). Other conidia are successively abstricted from the same conidiophore, which is true not only for this species but also for all the Leaf Mildews. In case of some of the Fungi only one conidial spore is formed by each conidiophore. In the Grape Mildew (Powdery Mildew) the conidiophores emerge from the stomate of

the leaf; they branch extensively and on each ultimate tip a conidium is produced (Fig. 5). Other forms of conidiophores and conidia are found in various fungi (as "White Rust" of Shepherd's purse (Fig. 14); and the Leaf-spot, or *Cercospora* of Celery (Fig. 8). In case of the large group of Fungi to which the Toadstools belong, the spores are borne on little pedicels (called *sterigmata*) that arise from a large cell which is called a basidium

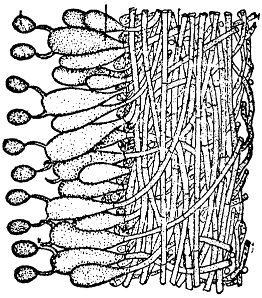

FIG. 10.

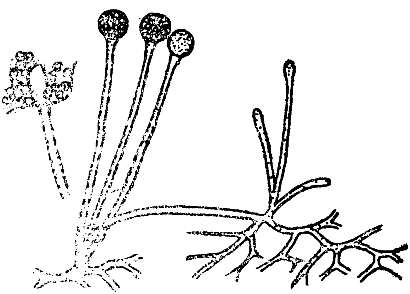

FIG. 11.

FIG. 10. A small section from the gill of an Agaric, or Mushroom, showing the hyphæ that terminate in Basidia which bear the spores.

FIG. 11. Hyphæ of the Mucor, or the common Black Mould, producing conidiophores that bear the conidia in receptacles at the apex.

(Fig. 10). Quite a different type of spore formation is seen in the common Black Mould. Here the sporophores are erect and develop within the enlarged terminal cell a multitude of conidia (Fig. 11). In other cases, for example, the fresh-water Alga called *Oedogonium*, the entire mass of protoplasm in a cell becomes a spore, develops cilia, *i. e.*, protoplasmic lashes or locomotive organs, and after escaping from the ruptured wall of the parent cell, swims about for a short time previous to permanent settlement and development into a filamentous form like the individual from whence it sprang. In case of Ulothrix, another of our common Algae, the protoplasm in a single cell becomes fragmented into two or many ciliated individuals, or swarm spores, which likewise are very active immediately upon their escape. When they come to rest their cilia disappear and soon a filament of the usual type is developed (Fig. 12).

SEXUAL REPRODUCTION.— It is not always the case that the single reproductive cell developes into the usual parent form; instead, if often unites with another like or unlike cell and the result of this union is the spore — the so-called *sexual-spore*, which then at once, or after a resting period, gives rise to the new individual. The essential feature of this process, sexual reproduction, is the fusion of the two nuclei of the *gametes* — as the two conjugating masses are called. The mechanism of the process is various in various groups of plants, but only a few illustra-

tions need be here given. For example, the common Black Mould, or Mucor, besides producing conidial spores is sometimes seen

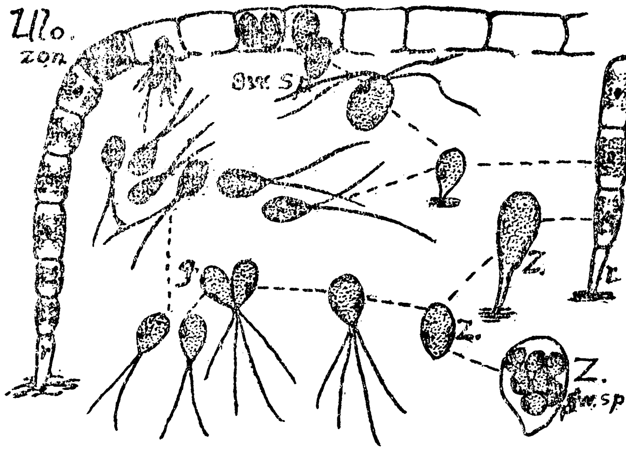

FIG. 12.

FIG. 12. Ulothrix zonata, a common fresh-water Alga, attached by a rhizoid (r), producing zoospores. The large swarm spores (sw. sp.) have four cilia. The smaller swarm spores have two cilia; in some cases they are gametes (g.) *i. e.* fuse to form a zygospore (z.). The zygospore may in turn produce swarm spores which grow into the usual form of the species; or the zygospore may develop, as many swarm spores do, directly into a plant like the ordinary filamentous form (Ul. zo.).

to produce sexual spores as follows. Two more or less differentiated hyphae give rise by the stimulus of contact to swollen portions each of which near the point of contact forms a septum

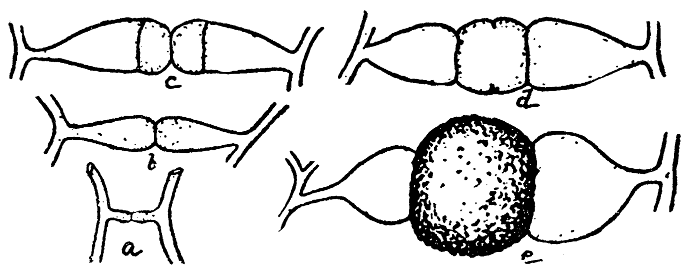

FIG. 13.

FIG. 13. Zygospore formation in the Mucor, or common Black Mould. An early stage of the gametophores is shown at *a*; the cells are becoming enlarged at *b*, and at *c* the gametes are formed; fusion is shown at *d*, and the mature zygospore is represented at *e*.

thus producing the two gametes. The common wall of these cohering cells becomes absorbed and the contents fuse into one mass and thus a single spore, *i. e.*, a sexual spore, is formed (Fig. 13).

To this is given the name of *zygospore* (yoke spore) because formed of two similar gametes. In case of some of the Mildews, the Albugo ("White Rust") of the Shepherd's purse, etc., the sexual process differs from the above mainly in the fact that the two parts or organs producing the gametes are quite unlike each

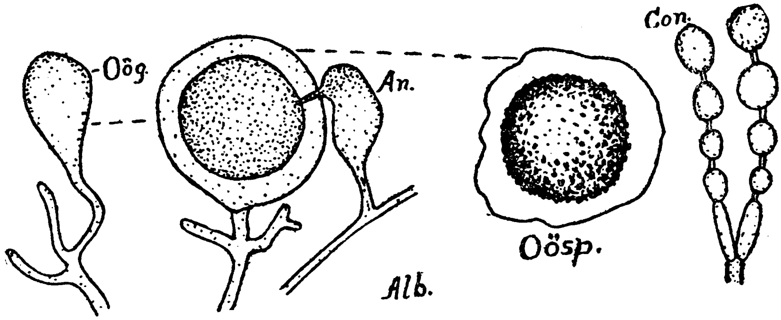

FIG. 14.

FIG. 14. Oospore formation in the so-called "White Rust" of the *Conciferæ*, Albugo candidus (Alb.). Conidia (Con.) of this species are also shown at the right. An early stage of the Oogonium (Oog.) is figured, followed by its feotilization by the Antheridium (An.). The mature Oospore is represented (Oosp.).

other (Fig. 14). The larger, or *egg-cell,* is designated as the *oogonium,* and the smaller one, or *sperm-cell,* is called the *antheridium.* The sexual spore in this case is called the *oospore.* The spore may have, in case of other groups, a mass of adjacent cells more or less completely enclosing it, developed simultaneously with the fusion of the nuclei or immediately before or after, the resulting structure suggesting a fruit — and hence such spores are called *carpospores.*

THE EVOLUTION AND PURPOSE OF SEXUALITY.— An examination of the probable origin of sexual reproduction in the vegetable kingdom may possibly indicate its purpose or advantages. Reference has already been made to swarm-spores — protoplasmic bodies destitute of a cell wall and furnished with a cilium, or two or more cilia, that serve the purpose of locomotion through water. When these zoöspores escape from the parent cell they swarm vigorously for an hour or more and then come to rest. Now it might happen occasionally in such apparently aimless motions that two of the cells would collide, perhaps fuse, and thenceforth act as a single cell; such has actually been observed to take place. That it merely "happens" so is indicated by the fact that most of the cells do not so collide and fuse, but each nevertheless develops independently into a new plant. If now anything in the way of vigor or other qualities proves valuable in such fortuitous union, the union of energies (that could never be *absolutely identical* in two separate masses!) might be a great

advantage, its results would be a positive gain to the race; it would therefore likely be perpetuated and the process become (by "selection") fixed and common. The fact that in some plants fusion of "swarm spores" is the rule, and that in the higher plants the gametes are brought together by aid of highly specialized structures suggests the correctness of this interpretation of the origin, and at the same time is probable proof of the advantages of sexual union.

VIEW POINTS IN SCIENCE.— The countless multitudes of plants and the endless variety in form and structure baffles an adequate comprehension of the Vegetable Kingdom. To understand, even in a general way, our common herbs, shrubs, and trees, we need to know their gross and minute structure, the relation and derivation of the organs and other specialized structures, their mode of living or physical and chemical energies displayed in growth, their relation to the environment in which they live, their reaction when untoward exigencies arise, their individual and their race development. Any one of these several *View Points* may for a time be made prominent; and a mass of knowledge — often more or less crude and quite insufficient — has already accumulated relative to each, and for which a technical designation is employed. Naturally the first phase to engage attention is the mere external form, and examination of the parts or organs presented — hence the term *Gross Anatomy*. With the aid of a microscope the minute anatomy can be determined satisfactorily so far as this instrument is able to reveal it. The masses of various kinds of material of which the organism is composed are called tissues; therefore the word *Histology* is used — the Greek word *histos* meaning tissue. But the various kinds of tissue in the plant-body and the organs presented may be studied with reference to their origin and mode of differentiation, and especially as to their fundamental relationship,— such a study is called *Morphology*. It includes an examination of the tissues and organs in *the act of development and differentiation*. It should therefore give us a correct interpretation of the parts of a plant and a clue to its meaning as a whole. When this developmental history is traced from the egg and carried through the remarkable changes in the early stages it is called *Embryology*. Structures that in the adult or mature form may be quite different in appearance or function may have been derived from the same, *i. e.* fundamentally corresponding, parts of the organism; they would then be said to be *homologous*. Thus the floral leaf — *e. g.* the stamen — is homologous with the foliage leaf; the panicle — *e. g.* the head of oats — is homologous with the Sunflower; the Fern leaves with their sporangia ("fruit") are homologous with the stamen and pistil in the Rose; the spore in the Lower plants is homologous with the cell from which the embryo in the seed of the higher plants develops. *Homology* — as this phase of

science is called — suggests a fruitful field of study in interpreting the apparently chaotic multitude of forms and structures.

PHYSIOLOGY.— The Point of View may not be primarily in relation to structure, but rather to the display of energy in the organism — in other words — its *Physiology*. This branch of science is therefore immediately concerned with such problems as — how the organism secures materials for food, the manner of breaking up chemical compounds into their elements and the recombination of these to form organic material, the various changes indicated by such terms as digestion, assimilation, respiration, as well as the protoplasmic reactions of all kinds displayed by the organism and the work it performs. Physiology has primarily to do with function rather than structure. But an organism may be studied as a whole or as a unit of energy, rather than in reference to the several phases of more or less intricate action displayed within the individual; its reaction to the medium in which it lives, its adaptation possibly to a slowly changing, or perhaps a more or less unfavorable environment, its behavior when untoward exigencies arise, or when other individuals or other objects or any external phenomena directly affect it;— these and other related topics are included under the head of *Ecology*. Ecological relations of plants are most intimately connected with their physiology — in fact Ecology might be considered one of the subdivisions of Physiology.

PHYTOPATHOLOGY.— Yet another relation should be mentioned, namely, that under which the untoward circumstances injuriously affect the individual. For example, a parasitic fungus may attack a leaf, or fruit, or stem or root, and interfere with its normal functions — ultimately, it may be, destroy the part or even the whole plant; a soil too rich in plant food or with deficient amount of one or more of the necessary food elements, or with insoluble compounds, may prove disastrous to the plant; or, again, mechanical influences may injuriously interfere with growth or cripple the organism; in all such cases pathological, or so-called diseased, conditions ensue. A study of the plant with special reference to such phases has developed a subdivision of Botany to which the name of *Phytopathology* has been appropriately given. When it is recalled that there is an enormous number of parasitic organisms — Rusts, Smuts, Leaf Mildews, Fruit-rots, Blights — that attack the cultivated plants, decreasing sometimes annihilating the crops, the practical importance of this branch of botany may be realized. The parasitic fungus may be microscopic in size and its presence known only by its disastrous effects; it may be wholly concealed within the tissue of the host — not always breaking through the epidermis even to liberate its spores; it may grow on the superficial cells though sending suckers into the epidermis of the host-plant for nourishment; it may be very simple in structure, even unincellular, or it may display consid-

erable differentiation; it may be polymorphic — that is, produce different kinds of spores in the different stages presented in the course of its life-cycle; the vast quantity of any one host-plant cultivated, as Wheat, Maize, the Potato, the Apple, the Grape, may afford practically unlimited food for the attendent parasite and so the destruction wrought would be almost incalculable. These facts not only indicate the importance of Vegetable Pathology, or Phyto-pathology, but suggest the very intimate relation of this subject with that of *Mycology*. The two can in fact be advantageously kept in mind in the future paragraphs of this elementary treatise.

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Alphabetical List of Articles, Authors, Subjects, New Species and Hosts, New Names and Synonyms.

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